Seismicity Parameters for Seismic Hazard Assessment in Alaska

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Investigations Undertaken:

1. We investigated the homogeneity of the earthquake catalog in interior Alaska (Zuniga and Wiemer, 1999) and mapped the minimum magnitude of completeness.
2. We extracted additional felt reports for seismic shaking from Alaskan news papers and combined this information with previously known intensities to map the maximum intensity reported throughout Alaska (Lu and Wyss, 1999).
3. We examined the details of the history of assessment of seismic hazard in the Adak segment of the Aleutian Islands because, to some, the 1986 M8 Andreanof island earthquake seemed a violation of the seismic gap hypothesis. We show that on the contrary the earthquake was expected on the basis of the elastic rebound theory and the hypothesis that seismic quiescence precedes some main shocks (Wyss and Wiemer, 1999).
4. We investigated aftershock sequences in Alaska, California, and Japan (Wiemer and Katsumata, 1999), with emphasize on the spatial and temporal homogeneity of the *b*- and *p*-values. We implemented the capability to evaluate the probabilistic hazard posed by large aftershocks of main shocks in Alaska.
5. We developed a system to take near-real time information on the occurrence of seismic events and provide rapid notification to government and private agencies responsible for seismic hazard mitigation (Lindquist, 1998).

Results:

The results of the research supported by this grant are detailed in one Ph. D. thesis (Lindquist, 1998), one article in press (Zuniga and Wiemer, 1999), two articles submitted for publication (Wyss and Wiemer, 1999; Wiemer and Katsumata, 1999) and one article in preparation (Lu and Wyss, 1999).

Homogeneity of Reporting of Earthquakes: We investigated the homogeneity of reporting in seismicity catalogs because the reliability of various methods to estimate the seismic hazard depends on the catalog quality. Since this is a general problem, we included the catalogs of Guerrero, Mexico, in addition to the Alaskan catalog in this investigation. For Interior Alaska we computed the standard deviate Z as a function of time by comparing the overall seismicity rate with the rate in a 3-year window. The maps of *Z*-values were inspected for all times. The most outstanding rate change is found around 1992.5. Since the *b*-value remained unchanged, the most reasonable explanation for the observed rate change around mid-1992 is a decrease in the detection ability of the network in Interior Alaska. Both case studies demonstrate the usefulness of systematic comparisons of the cumulative and non-cumulative frequency-magnitude distribution and of spatial and temporal mapping of the seismicity rates as a tool to investigate the homogeneity of earthquake reporting (Zuniga and Wiemer, 1999).

Minimum Magnitude of Complete Reporting: We mapped the minimum magnitude of complete reporting for Alaska and found that, for the years 1988-98, the minimum magnitude of completeness was Mc=1.5 in those parts of Alaska with the best coverage (for example near Anchorage and near Fairbanks). In most parts of Alaska Mc<2.4. In the panhandle Mc increases to above 2.5 near latitude 60° and further south it becomes Mc=3. In the far NE of the state Mc=2.8, and on Kodiak island Mc is typically 3.5 with higher values off shore. The history of seismic coverage in the Aleutians is checkered, with local networks being established and then dismantled again. Currently the Mc pattern is rapidly changing since new seismograph stations are being installed for volcano monitoring.

Maximum Intensity: We mapped the maximum intensities reported for all parts of Alaska because this value is to some degree a test of validity for estimates of the seismic hazard. Methods of seismic hazard estimates, which do not predict high hazards in areas that have experienced relatively strong shaking in the past, are not likely to be reliable. The converse is not true: Low historical shaking cannot necessarily be interpreted as an indication of low hazard. Given the short history of Alaska, it is likely that some areas have not been subjected to shaking by the maximum credible earthquake.

Seismic Hazard Estimates Near Adak: The seismic gap hypothesis has recently been criticized heavily and termed incorrect (Kagan and Jackson, 1995). Because the great earthquakes of the Aleutian-Alaskan subduction zone are important pieces of evidence in this debate, we investigated the case of the supposed failure of the gap hypothesis in the repeated rupture of part of the 1957 great earthquake by the 1986 Andreanof island M8 earthquake. We show that two lines of evidence investigated by two sets of authors indicated in 1980 and 1985, before this great earthquake, that a main shock was likely. First, Wahr and Wyss (1981) estimated the amount of slip that occurred in the M8.7, 1957 earthquake as only 2 m. Thus, they concluded that the recurrence time of ruptures in the Adak region may be very much shorter than expected for M9 class earthquakes. Second, Kisslinger (1985) predicted a large earthquake in the Adak segment of the Aleutians for the end of 1985 or the beginning of 1986. We conclude that the evidence analyzed by Wahr and Wyss (1981) and by Kisslinger (1985) clearly pointed to an approaching large earthquake, and thus the Adak segment was recognized as a mature seismic gap before the earthquake occurred. Therefore, this event did not violate the seismic rebound theory, nor the seismic gap hypothesis.

Characteristics of Aftershock Sequences: We investigated the spatial and temporal variability of seismicity in aftershock sequences such as the 1995 M6.2 Tatalina River (Interior Alaska) earthquake. Significant variations in both the *b*- and *p*-value (of the modified Omori law) were found for all aftershock zones investigated (Wiemer and Katsumata, 1999), with b-value ranging from 0.6 to 1.5 and *p*-values ranging from 0.7 to 1.6. Along with the *a*-value that describes the productivity of an earthquake sequence, *p*- and *b*- can be used assess the probability of a large and potentially hazardous aftershock. Probabilistic aftershock hazard assessment has been used on a routine basis in California for a number of years and we have now implemented the capability to assess aftershock hazard in Alaska in near real time.

Rapid Notification of Seismic Events: We distribute automated information on the location and magnitude of earthquakes, as they are processed with our near-real time earthquake monitoring system analyzing the data from the ~250 seismographs in Alaska. We believe this is a vital tool for emergency service organizations and private lifeline operation companies. Since many faults in Alaska are capable of M>7 earthquakes, we have developed software to alert on-call analysts within seconds of large P-arrivals, to notify pagers and to distribute pertinent information by email within minutes of the origin. The event parameters can be reviewed immediately by an analyst on a review station.

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Non-technical Summary:

We developed a system to locate earthquakes in near real time and notify immediately government and private agencies responsible for seismic hazard mitigation. We investigated the homogeneity of the earthquake catalog in interior Alaska and mapped the minimum magnitude of completeness. We show that the M8, 1986 Andreanof islands earthquake was expected on the basis of the elastic rebound theory and the hypothesis of precursory seismic quiescence, and that it was not a violation of the seismic gap hypothesis. A detail investigation of aftershock sequences, as a function of space and time, showed for the first time that the rate of decay as well as the magnitude distribution vary strongly. The implication for the understanding of generation of aftershock sequences are not understood yet, but they may be profound. We compiled a map showing the maximum intensities due to historical seismic shaking in Alaska.

Reports published:

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